Prospects for the Efficiency of Financial Markets in the Era of Artificial Intelligence Technology 2018-2030 Opportunities and challenges

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Received: 06/04/2024 **Accepted: 11/05/2024** **Published: 30/06/2024**

Abstract :

The study aims to present and analyze the relationship between Artificial intelligence and financial market efficiency By addressing the theoretical and historical framework of artificial intelligence in financial markets, and the financial markets efficiency theory as well as highlighting the importance of Artificial Intelligence in enhancing financial markets efficiency by utilizing the most recent AI technologies such as Natural language processing (NLP) programs, Sentiment analysis (SA), Explainable Artificial Intelligence (XAI), and the most important finding of the study is that artificial intelligence provides three essential elements for financial markets: information efficiency, reduction of trading costs, and mitigation of risks in financial markets, which are the basis of Fama's financial markets efficiency theory. There are also multiple challenges that face these markets, most importantly the black box problem,...., wrong signals. The most significant aspect that will distinguish the future of these financial markets is the increasing reliance on AI-driven algorithmic trading. This trend may provide an alternative interpretation of market efficiency theory in the presence of artificial intelligence, at least until 2030.

Keywords: Artificial Intelligence, Financial markets efficiency, Algorithmic trading, Financial markets.

JEL classification codes: G14, G15,G23,O16.

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Introduction

This era has seen rapid technological advancement, where artificial intelligence (AI) plays an important role in enhancing the efficiency of financial markets. Big data analysis and precise predictions, relying on the analysis of different variables such as past stock prices, economic and political news, technological developments, and global events are crucial for making more intelligent investment decisions and improving the performance of financial portfolios. Additionally, the use of algorithmic trading is among the advantages offered by artificial intelligence, clearing the way for improved investment strategies, reducing current and anticipated risks, making informed decisions regarding buying and selling securities, and asset selection. Despite the many advantages and investment opportunities that this rapid progress provides, opening new markets or expanding geographical scope, it also poses security and regulatory challenges that may arise in regulations and regulatory policies, affecting the operation of these markets. Additionally, changes in general economic conditions may negatively impact the performance of financial markets.

The problematic:

How can artificial intelligence technology impact the efficiency of financial markets, and what are the opportunities and challenges that may arise as a result of applying this technology?

From the main research question, the following sub-questions branch out :

- How does artificial intelligence technology help improve the future efficiency of financial markets? And how do AI applications assist in enhancing investment decision-making processes and analyzing data based on the quality and efficiency of information?
- How will artificial intelligence technology contribute to enhancing the ability to predict market trends and reduce expected costs and risks?

The hypothesis:

The main problematic of the study is based on the following hypotheses:

- Artificial intelligence technology helps enhance the efficiency of financial markets by improving the quality and efficiency of information.
- Artificial intelligence technology contributes to increasing the ability to predict market trends and reducing expected costs and risks.

The objectives of the study:

The importance of this study stems from the pivotal role played by the financial market in the economies of countries amidst the rapid development of information and communication technology, where artificial intelligence and its applications represent the latest advancements in this field.

- Clarifying the role and importance of artificial intelligence in the efficiency of capital markets.
- Exploring the theoretical framework of financial market efficiency.
- Highlighting the most important applications of artificial intelligence used in capital markets.
- Demonstrating the core differences between traditional trading with human intelligence and trading using artificial intelligence.
- Analyzing the future of financial markets in light of the development of artificial intelligence applications.
- Reviewing the advancements in artificial intelligence and how it constitutes a transformation in financial markets.

The importance of the study:

The study derives its importance from the following considerations:

- The pivotal role played by the financial market in any economy, which emphasizes the significance of studies in this field, especially those related to enhancing the efficiency of financial markets.
- The study helps in understanding how financial markets interact and adapt to artificial intelligence technology.
- It also provides the latest developments in information and communication technology and its applications in the financial market, especially algorithmic trading and machine learning.
- Additionally, it offers a clear insight into the future of artificial intelligence applications in global financial markets.

The methodology of the study:

In order to address the problem statement of the study and achieve its objectives, a descriptive-analytical methodology was followed. This involved describing and reviewing the theoretical aspects related to the concept of artificial intelligence and its relationship with the efficiency of the financial market. Additionally, future trends in artificial intelligence-based trading algorithms worldwide from the year (2021-2030) were discussed.

To answer the posed questions, the study will be structured within the following axes:

- **Axis 1:** The historical evolution of artificial intelligence in financial markets.
- **Axis 2:** The importance of artificial intelligence in enhancing the efficiency of financial markets.
- **Axis 3:** Applications of artificial intelligence in financial markets.
- **Axis 4:** Opportunities and challenges posed by artificial intelligence in financial markets.
- **Axis 5:** The inception and historical evolution of artificial intelligence in financial markets.

Axis 1: The historical evolution of artificial intelligence in financial markets.

In the 1950s, the term "artificial intelligence" was introduced for the first time by a group of scientists within the framework of the Dartmouth University Conference in the (DSR PAI) Project, under the supervision of a group of scientists, the most important of whom were John McCarthy and Marvin Minsky. The latter defined artificial intelligence as the construction of a set of computer programs that perform or participate in tasks typically performed by humans, and this in a more satisfactory manner. The search began for programs and tools capable of performing any task that humans could do. Despite their differences regarding the standard and mathematical methods to be used, they were the starting point for artificial intelligence (Council of Europe, 2024). By 1960, interest in this field began, and a huge budget was allocated to fund this research, leading to new horizons for financial markets, stimulating creativity and innovation in trading, and providing continuous and rapid support for investors to improve their performance and make sound decisions in the face of a changing or fast-changing environment. Thus, the first systems for making simple, limited, and inflexible decisions, such as financial data analysis, emerged, which were a set of pre-programmed transparent and simple programs that could be easily interpreted. This led to the search for systems and programs more adaptable to this environment. From the seventies to the eighties, new systems called **Expert Systems** or Expert Systems were developed, which are software that simulates the analytical skills of human financial experts aimed at making decisions in a specific field, including the financial field.

After in-depth and continuous research and studies, what is known as neural networks and machine learning algorithms appeared in the nineties, which are considered a significant advancement in the field of artificial intelligence and

financial markets. These algorithms are capable of learning and predicting based on this basis, as they can make decisions. This is evident in financial markets such as predicting stock prices and other assets and detecting fraud in transactions (Agrawal et al., 2019, pp.506-507) .In the late nineties, the European Commission allowed electronic exchanges, leading to **High-Frequency Trading(HFT)**. Since then, trading has become high-frequency, and by 2001, the execution of trades in high-frequency trading took only a few seconds. In 2010, trades were executed in milliseconds, and even microseconds and nanoseconds. In 2012, the New York Stock Exchange saw a 164% increase in high-frequency trading volume (Shashank, 2021, pp.4-5). During this period, many applications and programs supported by artificial intelligence and **Natural Language Processing (NLP),** and **Sentiment Analysis (SA)** emerged, which have played a significant role in financial markets, as they can analyze audio and text content related to business and financial services to analyze external factors such as the impact of social media on trading. Expert systems for classifying listed companies on the stock exchange and **Systems For Fraud Detection (SFD)** were developed from 2003 to 2009, followed by **Risk Management Systems(SMS)** in 2013. The latest developments in 2020 were in understanding how to access complex artificial intelligence and make decisions **Through Explainable Intelligence (XAI)** (Arrieta et al., 2019, p 2), making the decision-making process more transparent and understandable for human users.

Axis 2: The importance of artificial intelligence in enhancing the efficiency of financial markets.

In order to analyze the relationship between the variables of this research, namely artificial intelligence and financial market efficiency, it is necessary to first understand the nature of financial market efficiency through a set of definitions addressed by many researchers. At the forefront of these definitions, we find the contribution of Eugene F. Fama.

The first definition: The financial market reaches efficiency when three essential conditions are met. Firstly, there are no transaction costs. Secondly, all information is freely available to all market participants without cost. Thirdly, there is agreement among all participants on how information affects the current and future prices of each financial instrument (Fama, 1969, pp.387-389), according to Andrew W. Lo, the primary criticism directed towards this theory by psychologists and behavioral economists is that it is based on unrealistic assumptions and contradicts human behavior and rationality (Lo, p2007, pp. 1-2).

The second definition: The efficient market hypothesis (EMH) is based on the notion that the market is informationally efficient, meaning that asset prices reflect all relevant information as a consequence of investors competing to act on new information to maximize the value of their investment portfolios (Hodnett & Hsieh, 2012, pp.859-860).

In 1991, Eugene Fama observed that as transaction costs in the market, including the cost of obtaining information, decrease, market efficiency increases. This is known according to Basel II regulations as market discipline, referring to disclosure and transparency. Additionally, there are three different levels of market efficiency: the ability to predict returns (weak efficiency), adjusting prices based on new information (semi-strong efficiency), and examining information that can be retained on a personal scale (strong efficiency). Consequently, U.S. security markets are perceived to be relatively efficient. The informational efficiency of stock prices is significant for investors in two main aspects: firstly, investors are concerned about whether different trading strategies can outperform the market and generate excess returns. Secondly, if stock prices accurately reflect all available information, new investment capital is allocated to its most valuable use efficiently.

The third definition:

An efficient market is typically founded on two fundamental principles:

1. All available information is already reflected in stock prices.
2. Investors are unable to earn excess returns relative to the associated risks. (Degutis & Novickytė, 2014, pp.8-9)

From the above, this study can conclude that a financial market cannot be said to be efficient unless it is characterized by low transaction costs and efficient information (disclosure and transparency) and made available to everyone, which enables us to know current asset prices and predict future prices, thereby reducing potential risks, this has influenced the dynamics of these markets. We can elucidate the advantages that artificial intelligence offers to financial markets in the following aspects:

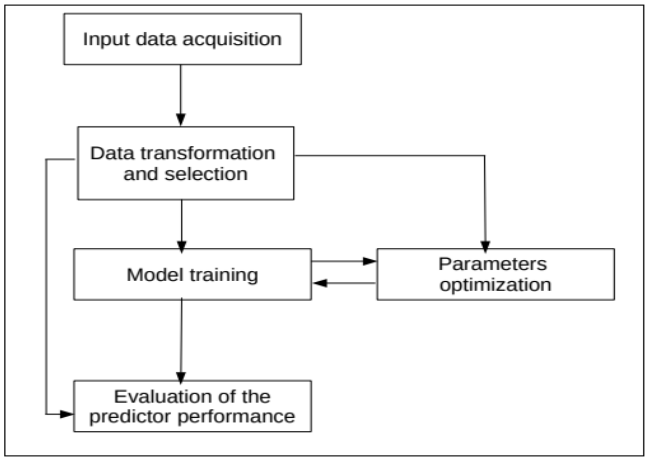
1- Improving Predictions and Analyzing Big Financial and Non-Financial Data in the Financial Market:

Artificial intelligence can be utilized to identify patterns in complex data, allowing for more accurate predictions of future performance. It can also automate processes such as financial transactions, enhancing efficiency, reducing costs,

contributing to decision-making, improving model accuracy, and reducing decision-making time. Additionally, artificial intelligence can identify complex economic changes and potential investment opportunities. (Rahmani & Rezazadeh, 2023, pp.2-3) AI techniques are leveraging massive alternative data sources for big data analytics, enabling ML models to autonomously enhance predictability and performance by learning from experience and data. (OECD, 2021)

The basic structure of an Artificial Intelligence prediction model used for forecasting is outlined in Figure (01). Initially, the process involves gathering all the required data to both train and test the model. This data is then processed, modified, or simplified to filter out details and emphasize information. Subsequently, the predictor utilizes this processed data to train its model with the possibility of tuning its hyperparameters during a validation phase. Ultimately the performance of the trained model, with optimized hyperparameters must be assessed in a testing phase.

Figure (01): Artificial Intelligence prediction steps



Source : (Ferreira et al., 2021, p11)

2-Artificial intelligence has the ability to transform:

It has greatly aided in improving the quality of predicting price movements, asset performance, and trading methods used by investors and brokers. A prime example of this is the adoption by major companies on Wall Street, such as: Goldman Sachs have started to focus on narrow AI solutions through data mining, natural language processing, and using self-learning algorithms tools (Kalyan, 2019, pp.18-19).

3-Developing trading strategies from traditional to algorithmic trading:

Algorithmic trading, also known as automated trading or black-box trading, refers to the trading of financial assets according to a predefined set of rules that have been tested on historical data (Pothumsetty, 2020, p140). These algorithms are designed to execute trades swiftly and with superior quality, tasks that would be nearly impossible for human traders. They rely on artificial intelligence techniques such as machine learning, deep learning from data and new variables, as well as big data in the market and adapting to it, to generate signals based on forecasts. These signals include predicting whether a specific financial asset's price will rise or fall within a certain period and guiding trading decisions, on whether to buy, sell, or hold that asset. These algorithms are intricately designed to seize market opportunities instantly, enabling traders to make informed decisions and enhance their overall profitability (Satnaliwala, 2024, p2), hence making intelligent decisions, in real-time. (Addy et al., 2024, p259) Additionally, it can be said that artificial intelligence has added several features to traditional trading, which can be further elaborated through the following table:

The differences between traditional trading with human intelligence and trading using artificial intelligence.

Table No. (01): Differences between Traditional Trading with Human Intelligence and Trading Using Artificial Intelligence.

Aspect	Traditional Trading with Human Intelligence	Trading with Artificial Intelligence
Decision-making process	Relies on human intuition and judgment	Utilizes algorithms and data analysis
Speed and Efficiency	Processing and execution speed may be slower	Executes trades quickly, often in milliseconds
Psychological Factors	Susceptible to emotional biases and irrational decisions	Free from emotional biases, decisions are based on data
Adaptability and Learning	Limited ability to adapt quickly to changing market conditions	Constantly learns and adapts to new data and market trends
Scale and Scope	Limited capacity to manage large volumes of data and securities	Can handle large volumes of data and manage complex portfolios
Risk Management	Relies on subjective risk assessment and may overlook certain risks	Incorporates advanced risk management techniques and data analysis
Intuition and Creativity	Relies on human intuition and creativity for decision-making	Lacks human intuition but excels in data analysis and pattern recognition

Source : (Sanghvi, 2023, p2)

4-Artificial intelligence provides new opportunities for trading:

Analyzing the effectiveness of these strategies in achieving profits and reducing risks by studying how artificial intelligence affects the development of algorithmic and automated trading strategies.

Trading using artificial intelligence involves using automated systems to conduct trading activities in financial markets. This process includes various operations such as data analysis, forecasting, and even placing and executing buy and sell orders - all without direct human intervention. In AI trading, complex algorithms and machine learning techniques are used to understand market trends, evaluate relevant information, and make trading decisions based on predefined instructions. The goal is to leverage the capabilities of artificial intelligence to enhance the efficiency and effectiveness of trading strategies while reducing the continuous need for direct human intervention (Kaur & Singh, 2021,p 803).

5-Improving the transparency of financial markets, risk management, and detecting fraud:

Techniques such as big data analysis, neural networks, and behavior analysis used in the securities market have provided highly useful information for making strategic trading decisions, leading to increased profits and reduced risks and fraud that may affect any market participant, whether individual investors or large or small companies, financial institutions, etc. (Kalyan, 2019, pp.18-19) Detecting and preventing fraud in risky transactions can be easily achieved through advanced artificial intelligence applications and deep learning.

In addition to the aforementioned, we note that artificial intelligence can work for long periods without fatigue, whereas humans may become tired and fatigued. AI has facilitated the automation of trading strategies for some traders, enabling them to capitalize on market opportunities day and night, without interruption. (Satnaliwala, 2024, pp. 2-3) making artificial intelligence an important option to avoid potential errors that may occur due to human fatigue (Kaur & Singh, 2021,p 804).

6-Enhancing information efficiency and the ability to learn and adapt to constantly changing market conditions :

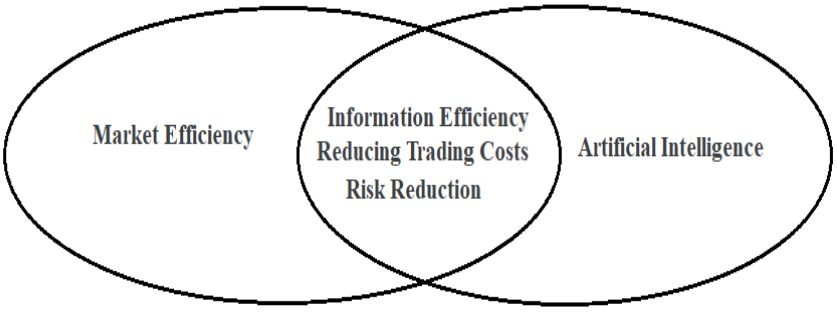
One of the primary advantages of employing AI in stock trading lies in its capacity to quickly and effectively process extensive volumes of data. Human traders frequently encounter difficulties in analyzing real-time information comprehensively, which can result in missed opportunities or decisions based on

incomplete data. In contrast, AI algorithms are capable of processing millions of data points within seconds, enabling traders to make more timely and well-informed decisions. Additionally, AI algorithms can simultaneously analyze multiple variables and detect intricate patterns that may elude human traders. This ability to uncover hidden patterns provides AI-driven trading systems with an advantage in forecasting market trends and executing profitable trades. For instance, AI algorithms can identify correlations between stock prices and various economic indicators, such as interest rates, inflation, or consumer sentiment. By considering a broader array of factors, AI algorithms can make more precise predictions and adjust to evolving market conditions. Another benefit of utilizing AI in stock trading is its capacity to learn and enhance performance over time. Machine learning algorithms can continuously analyze and adapt to new data, refining their trading strategies based on previous experiences. This feature enables AI-driven trading systems to become increasingly accurate and efficient over time, as they adapt to shifting market dynamics and improve their overall performance (Kalyan, 2019, pp. 18-19).

Based on all of the above, we can infer the relationship between financial market efficiency and artificial intelligence techniques in three key elements, as illustrated in Figure(02):

- **First:** Information efficiency in financial markets;
- **Second:** Reducing trading costs in financial markets;
- **Third:** Minimizing risks in financial markets.

Figure(02) : The relationship between market efficiency and artificial intelligence



Source : prepared by the researcher

Axis 3: Artificial Intelligence (AI) based applications in Financial Markets.

Artificial intelligence is applied in the financial field in three main areas:

- Improving investment portfolios;
- Predicting future prices or trends in financial assets;

- Analyzing sentiments related to assets or companies from news or social media (Ferreira et al., 2021, p1).
-

In the context of artificial intelligence, there are algorithms used to predict stock market movements based on past data and several other variables. Market trends are analyzed, and research is conducted to improve prediction accuracy. Furthermore, emphasis is placed on the vital role of investors' use of predictive applications in the stock market. Here are some AI-based applications that have become increasingly popular for forecasting market trends (Srivastava & Sengupta, 2017, pp. 74-75) :

- **Sentient Technologies**: is a multinational technology company based in America, focusing on developing artificial intelligence technologies. It primarily operates on a trading platform where companies have built billions of AI traders. Most of the funding for this application comes from AI startup companies, estimated at around $135 million.

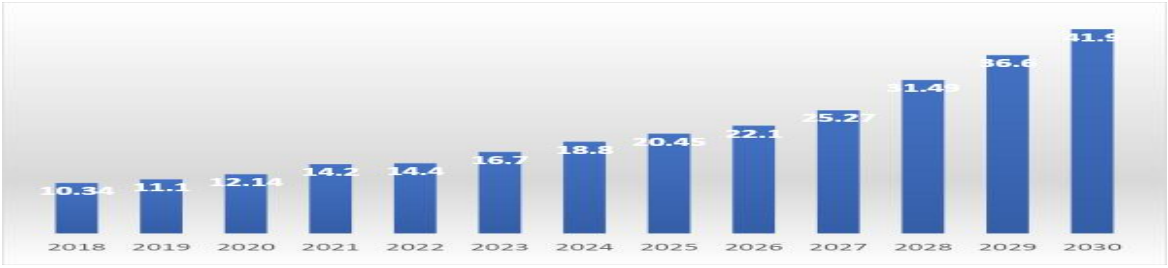
-. **Clone AlgoInc:** is a multinational company based in the United States. It is a technology company that primarily creates AI-based algorithms for financial trading and mobile applications

- **Alpaca:** is a California-based startup focusing on AI technologies and database rules to improve financial trading. Alpaca operates on the AlpacaAlgo platform, a web-based service that automatically executes trading ideas using deep learning. The company indicated that it had executed a trading volume of $100 million in less than two months.

- **Walnut Algorithms**: is a French startup focusing on technology and applying the latest developments in data science and machine learning in financial markets. The company combines advanced machine learning techniques costing $446,000 with financial expertise to create high-yield investment strategies. Sophisticated trading models have been created capable of continuous learning and improvement, seeking high levels of confidence in financial markets and smart adaptation to changing market conditions.

In addition to the above, the use of algorithmic trading based on artificial intelligence has become the basis of international financial markets. It has also increased very quickly, and this increase is expected to continue until 2030, and the following figure shows this.

Figure (03): The Future of Artificial Intelligence Trading Algorithms Worldwide Year (2018-2030)



Source : (Spherical Insights, 2022)

The algorithmic trading sector experienced growth in 2021 reaching a value of $13.02 billion. This surge reflects the increasing reliance on technology and artificial intelligence as drivers within this industry. Projections suggest that the market value is set to double by 2030 hitting $31.30 billion with a compound annual growth rate of 13.6% from 2021 to 2030. The consistent 13.6% compound annual growth rate underscores the enduring robustness of this sector with advancements and algorithmic progress expected to propel its momentum. Additionally artificial intelligence plays a role in market evolution by enhancing the efficiency of trading processes and offering signals, for informed trading choices.

Many of the world's large investment companies, managing high-value investment portfolios, increasingly utilize algorithmic trading for various asset classes, especially between 2020-2021-2022. This surge in the use of AI-driven algorithmic trading can be attributed to seven key reasons: ease of use, market impact reduction, lower commission rates, obtaining better prices, increased speed, customization, and pre-trading estimates (forecasts). The following table illustrates this:

Figure (04) : Reasons For Using Algorithms Trading (% of responses)

Feature	2022	2021	2020
Ease of use	▲ 12.25	12.04	11.08
Reduce market impact	▲ 12.03	10.45	10.29
Increase trader productivity	▲ 10.87	10.32	10.45
Consistency of execution performance	▲ 10.74	10.19	10.51
Better prices (price improvement)	▲ 7.94	6.68	6.65
Greater anonymity	▼ 7.85	8.96	9.93
Flexibility and sophistication of sor	▲ 7.35	7.24	8.02
Higher speed, lower latency	▼ 6.87	7.64	6.56
Lower commission rates	▼ 6.77	8.69	6.83
Customisation capabilities	▲ 6.33	6.21	5.74
Algo monitoring capabilities	▲ 5.67	5.30	7.20
Data on venue/order routing logic or analysis	▲ 3.93	3.84	5.07
Results match pretrade estimates	▼ 1.39	2.45	1.67

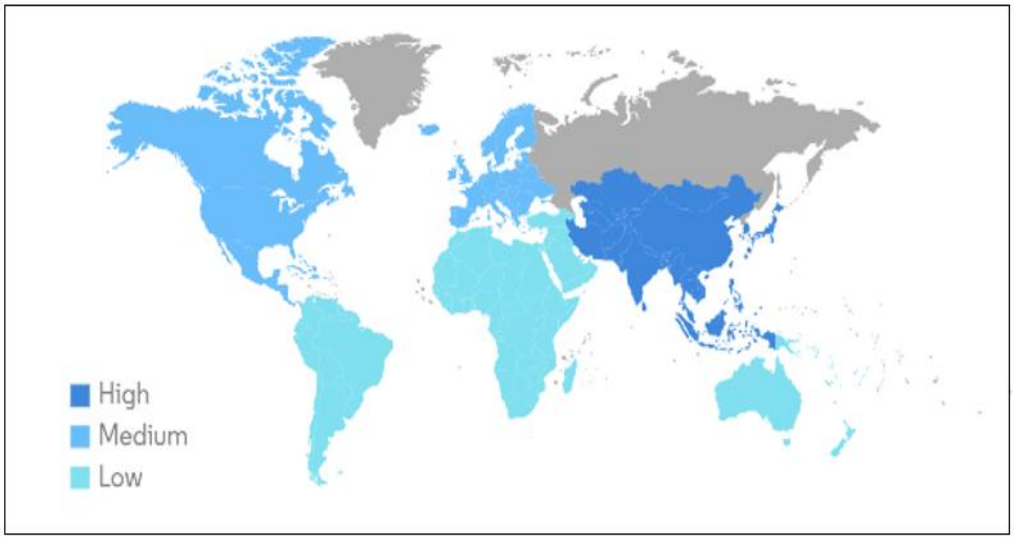
Source : (Aite Group, 2022, P73)

The table illustrates the reasons for resorting to AI-driven algorithmic trading and the priorities and concerns for each reason during the selected three years: 2020, 2021, and 2022. We observe an increase in the percentage from year to year for each of them.

- Ease of use;
- Reduce market impact;
- Increase trader productivity;
- Consistency of execution performance;
- Better prices (price improvement);
- Flexibility and sophistication of sor;
- Customisation capabilities;
- Algo monitoring capabilities;
- Data on venue/order routing logic or analysis.

This provides a general idea about the status of artificial intelligence in financial markets.

Figure (05) : Algorithmic Trading Market (Growth Rate By Region 2022-2027)



Source : (Modor Intelligence, 2019)

The most important conclusion that can be drawn is that the capital markets in the United States and Europe are more inclined towards the use of artificial intelligence through algorithmic trading. As for the markets experiencing the fastest growth in the use of artificial intelligence, they are the countries in Southeast Asia and China.

Axis 4: Opportunities and challenges posed by artificial intelligence in financial markets.

Artificial intelligence has achieved remarkable results in capital markets, surpassing many tasks performed by participants in these markets in terms of efficiency and effectiveness. However, this achievement is not without challenges facing the activity of these markets in general and their efficiency in particular. Among the most important of these challenges are:

- One primary obstacle involves the risk of overfitting, where algorithms specialize excessively in predicting historical data but struggle to perform effectively on new, unseen data. Overfitting poses a significant concern, potentially leading to inaccurate predictions and false signals, thereby exposing traders to potential financial losses. (Kalyan, 2019, pp.18-19)
- Another challenge pertains to the interpretability of AI algorithms. Traditional trading methods often rely on a degree of intuition and human judgment, enabling traders to comprehend and articulate their decision-making process. In contrast, AI algorithms can be intricate and opaque, presenting challenges for traders seeking to understand the underlying rationale behind their predictions. (Kalyan, 2019, pp. 20-21)
- A significant issue regarding the transparency and interpretability of decision-making using artificial intelligence is often described as the "black box problem." This term refers to the difficulty in understanding how complex AI models and machine learning arrive at their decisions. Regulators and traders must establish mechanisms to ensure transparency and accountability in AI algorithm decision-making due to the complexity and opacity of these algorithms, making it difficult for traders to understand their predictions.
- The rapid technological advancement of artificial intelligence also poses a challenge to capital markets, as it leads to a lack of alignment between legal regulations and the need for better regulation of these transactions. This misalignment creates new risks that require more time to address.

The incorporation of artificial intelligence (AI) into algorithmic trading has introduced a multifaceted ethical and regulatory environment, necessitating thorough examination of algorithmic bias, risks, regulatory frameworks, and ethical aspects. One of the primary ethical dilemmas in algorithmic trading concerns the potential bias inherent in AI models – Algorithmic bias occurs when machine learning models produce results that systematically disadvantage or favor certain groups. In trading, bias can manifest in various forms, including discriminatory order execution or unequal access to market information. It is essential to ensure fairness and mitigate bias in algorithmic trading algorithms to

uphold market integrity. Market participants and developers must implement measures to identify and address bias, thereby fostering fair and equitable trading environments (Addy et al., 2024, p 262).

- Deep learning and natural language processing empower the analysis of unstructured data, such as news articles and social media feeds, enabling AI to extract valuable insights and provide traders with a more comprehensive market view for better decision-making. The opposite is also true, meaning that fake and fabricated news on social media platforms may influence misleading decisions by traders in these markets (Kalyan, 2019, pp. 19-20).
- Enhanced asset management and buy-side activity, along with improved liquidity management and execution of large orders with minimal market impact, are achieved through ML models' ability to identify signals and capture underlying relationships in big data.
- Optimization of operational workflows and risk management, leading to increased efficiencies, includes streamlining execution and producing efficiencies in risk management and order flow management (OECD, 2021).

Conclusion:

The use of artificial intelligence has made a significant difference in financial markets in recent times, present, and future. It has become an important tool for improving the quality of predicting price movements and asset performance, as well as analyzing big data quickly and efficiently. Additionally, it has the ability to learn and adapt to changing market conditions through the use of advanced AI technologies such **Expert Systems, natural language processing (NLP)** and **sentiment analysis (SA) through explainable intelligence (XAI)…,** These technologies also allow for enhancing market transparency and making information available to all parties. Furthermore, big data analysis and neural networks contribute to reducing risks and minimizing increasing fraud experienced by stakeholders and brokers. The study found that some of these advantages intersect with what is known as market efficiency, characterized by the absence of transaction costs, the availability of all information freely to all market participants, and the agreement among all participants on how information affects the current and future prices of each financial instrument, ultimately leading to a balance between market values and realities. The study identified three fundamental elements shared between artificial intelligence and market efficiency:

- Information efficiency

- Reducing transaction costs
- Risk reduction

The study also found that the increasing reliance on algorithmic trading techniques worldwide and the growing research on smart trading solutions are attributed to the rapid execution of transactions, often in less than a second, freeing traders from psychological biases and enabling objective decision-making. Additionally, continuous learning and adaptation to new data and market conditions, along with the ability to handle massive amounts of data and manage large portfolios, are facilitated by advanced risk management techniques. Despite the lack of human intuition, creativity, and emotion, artificial intelligence excels in data analysis, leading to a significant increase in the growing reliance on AI technologies. This reliance rose from $10.34 billion in 2018 to $16.7 billion in 2023, with an expected doubling by 2030 to $41.9 billion, with an annual growth rate of 13.6%. The American financial markets are considered the most reliant on artificial intelligence, while the fastest-growing markets are in Southeast Asia and China. The future differentiation of market efficiency will be characterized by the continuous development of this technology, where artificial intelligence, through trading algorithms and deep learning, makes proactive decisions rather than reactive ones, such as suggesting future investments in specific assets, gradually reducing human intervention. The efficiency of financial markets in terms of transaction costs, transaction speed, and decision-making will heavily depend on artificial intelligence technologies, which may provide an alternative interpretation of market efficiency theory under artificial intelligence at least until 2030.

References

1. Addy, W. A., Ajayi-Nifise, A., & Bello, B. (2024). Algorithmic Trading And AI: A Review Of Strategies And Market Impact. In World Journal Of Advanced Engineering Technology And Sciences.
2. Agrawal, A., Gans, J., & Goldfarb, A. (2019). The Economics Of Artificial Intelligence: An Agenda. University Of Chicago Press.
3. Aite Group. (2022). Algorithmic Trading Survey.
4. Arrieta, B., Rodríguez, A., & Rodríguez, D. (2019). Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities And Challenges Toward Responsible AI. Information Fusion. 58. 10.1016/J.Inffus.2019.12.012.
5. Council Of Europe. (2024). Council of Europe and Artificial Intelligence, Www.Coe.Int/Ai (Consulted on 12/10/2023).
6. Degutis, A., & Novickytė, L. (2014). The Efficient Market Hypothesis: A Critical Review Of Literature And Methodology,. In Ekonomika (Vol. 93).

7. Fama, E. F. (1969). Efficient Capital Markets: A Review Of Theory And Empirical Work Source. In The Journal Of Finance (2nd Ed., Vol. 25). Papers And Proceedings Of The Twenty-Eighth Annual Meeting Of The American Finance Association New York, N.Y.
8. Ferreira, F. G. D. C., Gandomi, A. H., & Cardozo, R. T. N. (2021, 02). Artificial Intelligence Applied To Stock Market Trading: A Review (Vol. 9). Ieee Access.
9. Hodnett, K., & Hsieh, H.-H. (2012, 08). Capital Market Theories: Market Efficiency Versus Investor Prospects. In International Business & Economics Research Journal (8th Ed., Vol. 11).
10. Kalyan, C. E. (2019). Use Of Artificial Intelligence In Stock Trading. In MPRA Paper. University Library Of Munich, Germany.
11. Kaur, M., & Singh, S. (2021). Application Of Artificial Intelligence In Stock Market Trading. In Manmeet Singh Niu International Journal Of Human Rights (3rd Ed., Vol. 8).
12. Lo, A. W. (2007). Efficient Market Hypothesis. In The New Palgrave: A Dictionary Of Economics. EKONOMIKA.
13. Modor Intelligence. (2019). Algorithmic Trading Market.. www.Mordorintelligence.Com/Ar/Industry-Reports/Algorithmic-Trading-Market (Consulted on 04/11/2023)
14. OECD. (2021). Artificial Intelligence, Machine Learning And Big Data In Finance : Opportunities, Challenges, And Implications For Policy Makers. Https://www.Oecd.Org/Finance/Artificial-Intelligence-Machine-Learningbig-Data-In-Finance.Html (Consulted on 11/10/2023)
15. Pothumsetty, R. (2020). Application Of Artificial Intelligence In Algorithmic Trading. In International Journal Of Engineering Applied Sciences And Technology (12th Ed., Vol. 4).
16. Rahmani, A. M., & Rezazadeh, B. (2023). Applications Of Artificial Intelligence In The Economy, Including Applications In Stock Trading, Market Analysis, And Risk Management,.
17. Sanghvi, H. (2023). How Artificial Intelligence Is Transforming The Stock Trading Industry.
18. Satnaliwala, M. (2024). Unveiling The Role Of Artificial Intelligence In Market Predictions,. In International Journal For Multidisciplinary Research (1st Ed., Vol. 6).
19. Shashank, B. (2021). Evolution Of Algorithmic Trading And Assessing The Impact Of It On Capital Market. The ICFAI University, Hyderabad.
20. Spherical Insights. (2022). The Future Of Artificial Intelligence Trading Algorithms Worldwide Year (2018-2030). Https://Www.Sphericalinsights.Com (Consulted on 06/01/2024)
21. Srivastava, A., & Sengupta, I. (2017). Predicting Stock Market: An Approach With Artificial Intelligence. In Management Insight - The Journal Of Incisive Analysers (2nd Ed., Vol. 13).